

Similar though much fainter touches inferiorly proceed on the anal fin. Traces of the line of pigment seen at the younger stage a little above the ventral border of the abdomen are still present; but all the reticulations just described have been developed subsequently and independently. The median ventral pigment-line is also quite distinct from the branchiostegal region to the vent. The modification of the numerous and somewhat small lateral reticulations into the larger vertical bars of the adult is easily observed in a series, as also the gradual diminution of the pectorals. A characteristic feature of this young stage is the presence of a K-shaped arrangement of black pigment on each side of the head, the strong bar of the K uniting with its fellow over the brain and proceeding forward over the eye to the tip of the snout. One leg of the K goes from the eye straight downward to the edge of the mandible, while the other slopes backward to the opercular region.

The earlier stage here described would appear to represent a season's growth, and, indeed, it is possible that the later stage referred to is a form about two months older.

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XXIII.—*On the Anatomy of Sesia tipuliformis and Trochilium apiforme*, Linn. By Prof. E. K. BRANDT\*.

Two years ago, while studying the anatomy of *Sesia scolioformis*†, I discovered that the structure of the moth differs much from the usual Lepidopterous type, and I thought it would be interesting to compare the connexion between the outward form and the internal structure of other moths belonging to the same group. In the summer of 1887 I had an opportunity of dissecting several specimens of *Sesia tipuliformis* and *Trochilium apiforme*, and ascertained by repeated experiments that they agreed in most essential points.

\* Translated from the Russian by W. F. Kirby, F.L.S., F.E.S., &c. [The accompanying paper was written in June 1888, and published in 'Horæ Societatis Entomologicæ Rossicæ,' vol. xxxii. pp. 41-49, in 1889. I have not seen any translation or abstract elsewhere; and as the subject, relating to a very aberrant group of Lepidoptera, is of considerable interest and importance, and the languages of Eastern Europe are at present unfamiliar to many entomologists, I thought it might be useful to give the article a somewhat wider circulation.—W. F. K.]

† [This insect is very rare in England, and fresh specimens would be unattainable for dissection; but the other two species discussed in this paper are sufficiently abundant.—W. F. K.]

The anatomy of the Clear-wings is particularly interesting, because these moths exhibit obvious mimicry. The most remarkable point about the anatomy of *S. scoliaeformis* is that this mimicry does not originate in the perfect state, but exhibits a partial arrest of development at the normal condition of the pupa-state. The imperfect scaling of the wings may be thus explained; for the scales of Lepidoptera are developed gradually during the formation of the pupa. A similar arrest of development at some stage in the formation of the pupa is likewise visible in the internal structure. This shows that the Clear-wings are probably ancient forms which have latterly acquired a special adaptation to (or mimicry of) other flower-frequenting insects.

The present paper includes my observations on the dissection of three specimens (one male and two females) of *Sesia tipuliformis* and two specimens (male and female) of *Trochilium apiforme*.

#### *Sesia tipuliformis.*

The *skeleton* exhibits the same peculiarities which I had already noted in *S. scoliaeformis*. It deserves special attention that there are three distinct thoracic segments in these Clear-wings.

As regards the *mouth-organs*, the proboscis is moderately developed but very weakly constructed.

The *nervous system* is composed of nine ganglia, viz. two cephalic (supra- and infra-oesophageal), three thoracic, and four abdominal. The supra-oesophageal ganglion is well developed and exhibits considerable and well-marked sinuities; the visual parts are broad, thick, and short. The infra-oesophageal ganglion is small and placed very near to the supra-oesophageal. The first thoracic ganglion is placed nearer to the infra-oesophageal than to the second thoracic ganglion, but the second and third thoracic ganglia are very near together. The abdominal ganglia are rather small and placed at equal distances apart. The last thoracic ganglion is larger than the rest and distributes nerves to the various limbs and also to the reproductive organs and to the straight intestine. The nervous system is arranged on the same principle in both *Sesia tipuliformis* and *scoliaeformis*, but is arrested in development, for we find here three thoracic ganglia, as is usually the case in the pupa, whereas only two separate thoracic ganglia are usually present in the imago in the typical nervous system of Lepidoptera.

The digestive organs exhibit the following parts:—(1) the

œsophagus, (2) the crop, (3) the stomach, (4) the intestine. The last is distinctly divided into the small and large intestine, and is furnished with a blind branch (the cæcum). The œsophagus is a very long and narrow tube, which is gradually dilated at the lower end, and thus forms a large sac-like crop, opening into the œsophagus at the wide part. The stomach is of an oval shape, very narrow at each end. The small intestine is much more slender and does not form any expansions. At the commencement of the intestine appears a pear-shaped branch, which is the blind intestine (cæcum).

With regard to the morphological importance of the digestive apparatus, I think it possible that it represents about half the usual development in typical Lepidoptera. But the peculiar structure of the crop indicates an arrest of development in the pupa-stage. The crop does not communicate with the middle of the œsophagus, as is normally the case in Lepidoptera, but is placed near the lower end and communicates with the hinder part, not by means of a long slender canal, but, on the contrary, it opens into the œsophagus at the broad end, imperceptibly passing into the sac-like portion. The crop is formed thus in the last stage of the development of the digestive apparatus in the pupa, when it is not placed any more forward, and its commencement does not form a stalk.

The salivary glands are feebly developed. They consist of two long slender tubes, one end of which opens into the lower part of the mouth; the other end is usually rounded.

The Malpighian vessels present no peculiarity, being arranged on the usual type found in Lepidoptera. On each side of the alimentary canal are two vessels, opening into the commencement of the small intestine. Each vessel consists of two tubes, one of which is simple, but the other forms a connexion between the two vessels. Near the openings of the two Malpighian vessels they form a very small oblong expansion, the rudiment of a urinary bladder.

The heart or dorsal vessel is a long and rather narrow tube with several constrictions. There are eight chambers and attachments for the alæ musculares on the dorsal surface.

The respiratory system is arranged as follows:—There are two large respiratory tubes on the ventral surface, running along the whole trunk of the insect, and communicating with it by means of two transverse arching tracheæ. At the hinder end of the body they are connected by means of a transverse tube. Numerous fine branches are distributed to the various internal organs, and from these also run smaller transverse branches which communicate with the spiracles. The air-

cavities or air-vessels are not yet tracheæ. In this respect the Sesiidæ differ much from the Sphingidæ, in which they are placed together in one cluster in front, and in which such vesicles or sacs are absent in the transverse branches of the tracheæ on the ventral surface.

The male sexual apparatus of *S. tipuliformis* consists of the following parts:—(1) the testes, (2) the deferent ducts, (3) the *vesiculæ seminales*, (4) the *ductus ejaculatorius*, (5) the penis, (6) the accessory glands.

The *testes*, as is invariably the case in Lepidoptera, are two in number, and are enclosed in a common sac or scrotum. The *deferent ducts* are short and broad, opening into the *vesiculæ seminales*, which are small oblong sacs. The *ductus ejaculatorius* is a long sinuous tube. The *penis* is horny, with a guitar-shaped depression in the middle. The *accessory glands* are long and very sinuous.

The female sexual apparatus of *S. tipuliformis* consists of the following parts:—(1) the two ovaries, (2) the oviduct, (3) the vagina, (4) two accessory glands, (5) *receptaculum seminis*, (6) unpaired accessory gland, (7) copulatory pouch, and (8) ovipositor.

While investigating the anatomy of *Sesia scoliceformis* I noted a remarkable peculiarity in the structure of the ovaries. Each ovary contains fourteen tubes, each of which emits a small excretory canal. Every two canals unite, forming seven egg-tubes, which then combine to form one oviduct on each side, and afterwards unite at the vagina. This peculiarity in the structure of the ovaries is very remarkable and constitutes an exception to their usual type in Lepidoptera. In all other Lepidoptera hitherto examined there are only four egg-tubes in each ovary. It would be very interesting to discover whether the same anomaly in the structure of the ovaries is to be met with in other species of *Sesia*, or whether it is peculiar to *S. scoliceformis*. On dissecting *S. tipuliformis* I found that it exhibited the normal structure of the ovaries. I only count four egg-tubes in each ovary. These ducts are long, rather narrow, and only slightly constricted, so that they form straight rather than undulating tubes. The short broad oviducts open into the long vagina, which is considerably dilated at the end. There are two accessory glands, each of which is constructed of a broad pear-shaped part, opening into the vagina, and a long narrow tube, coiled in the peritoneal cavity. The unpaired supplementary gland consists of a long, narrow, stalk-like tube, opening at the lower end of the vagina. The *receptaculum seminis* is a long narrow tube, with the rounded end coiled in the cavity of the

body, but the narrow hinder end opening into the vagina. There is also a connecting canal extending from the middle of the *receptaculum seminis*, and opening into the efferent channel of the copulatory pouch—the small round sac which terminates in a separate external opening by means of a separate canal.

The structure of the female reproductive organs exhibits considerable development. It hardly differs from the usual Lepidopterous type except in the absence of branching fatty glands. There is, however, a very slight trace of deviation from the normal type, seen in the imperfect development of certain parts.

#### *Trochilium apiforme*, Linn.

The skeleton exhibits the same peculiarities of structure which are characteristic of *Sesia tipuliformis* and *scoliaeformis*.

The nervous system likewise exhibits the same arrangement, showing the remarkable arrest in the development of the insect in the pupa state. There are nine ganglia—two cephalic (supra- and infra-oesophageal), three thoracic, and four abdominal, of which the last is the largest.

The digestive system exhibits the following parts:—(1) the oesophagus, (2) the crop, (3) the stomach, (4) the small intestine, (5) the large intestine, provided with a blind branch (the caecum). The oesophagus is very long and narrow and is enlarged at the lower end. The crop exhibits the dilatation of the lower and lateral end of the oesophagus at its side, as in the pupa. It remains in that condition when it changes from the lower to the lateral position. The crop is narrower and longer than in *Sesia tipuliformis* and *scoliaeformis*, and opens into the stomach by a short broad stalk. The remainder is longer and narrower. The blind appendage is comparatively short, but the large intestine, behind the blind branch and the caecum, is broad and thick, as in *Sesia tipuliformis* and *scoliaeformis*.

The salivary glands are two long slender tubes, constructed throughout exactly as in the two *Sesiae*, and opening into the mouth in just the same way.

The Malpighian vessels exhibit the typical structure. There are three on each side of the intestine. Two of these unite in a common canal, but the third joins them, and then they all terminate in a common canal, opening at the commencement of the small intestine. This common canal is shorter, wider, and thicker than in *S. tipuliformis*. The Malpighian vessels themselves are very long and sinuous



tubes. The amalgamated Malpighian vessels exhibit no dilatation near the opening of the intestine.

The heart or dorsal vessel is constructed exactly as in *S. tipuliformis*.

The respiratory system consists of two large respiratory tubes, placed at the sides of the abdomen, and composed of the united respiratory tubes which run from the tracheæ. These abdominal respiratory tubes are continued to the thorax, and subdivide. At the hinder end of the abdomen the two main respiratory tubes are united in a curve, but there is no connexion between them at any other part of their course, and thus they differ from the respiratory tubes of *S. tipuliformis*, in which the conducting respiratory canals are connected by wide respiratory tubes at each segment.

The male reproductive system is of the same form and construction as in *S. tipuliformis*. It includes:—testes, contained in a common scrotum; two deferent ducts, opening into the large round *vesiculæ seminales*; the *ductus ejaculatorius*, shaped like a long sinuous tube; a horny penis, provided with a furrow; and two long, sinuous, accessory glands.

The female reproductive system consists of the following parts:—(1) two ovaries, (2) two oviducts, (3) vagina, (4) copulatory pouch, (5) *receptaculum seminis*, (6) one unpaired accessory gland, (7) two paired accessory glands, and (8) ovipositor. Each ovary consists of four very long sinuous egg-tubes. These four tubes unite into one common oviduct, and then both oviducts open into the vagina. The *receptaculum seminis* is a little round sac, which opens at one end into the copulatory pouch and at the other into the vagina. The unpaired accessory gland resembles a long, narrow, sinuous tube, provided with two short, rounded, bag-like processes at the upper end. The paired accessory glands resemble two short sinuous tubes. The copulatory pouch is an oval and rather large sac, which opens outwards by a separate outlet through the deferent canal, but which communicates with the *receptaculum seminis* by a connecting tube, and appears to be indirectly connected with the vagina.

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XXIV.—*On the Circulatory System of the Carapace in the Decapod Crustacea.* By E. L. BOUVIER\*.

THE circulatory system of the Decapod Crustacea, as described in the classic memoirs, after the investigations of Lund,

\* Translated from the 'Comptes Rendus des Séances de l'Académie des Sciences,' tome cx., June 9, 1890, p. 1211 *et seq.*